REMARKS

The Examiner has subjected this application to restriction under 35 U.S.C. 121. The Examiner has formed two groups of claims, Group I drawn to claims 1-17 and 45-49 for a photonic crystal, a structure and a device, and Group II drawn to claims 18-44 for processes of the invention. The Examiner has asserted that these groups of claims represent distinct inventions and may properly be restricted. Applicants have provisionally elected claim Group I to claims 1-17 and 45-49 for examination. That provisional election is hereby confirmed. However, the restriction requirement is traversed. It should be noted, the Commissioner may statutorily require the election of inventions "If two or more independent <u>and</u> distinct inventions are claimed in one application." In the instant case the Examiner is alleging that the inventions of groups one and two are distinct, although absolutely no <u>showing</u> of such distinctness has been made.

The Examiner's attention is directed to 37 C.F.R. 1.141(b) where allegedly different classes of inventions may be included and examined in a single application provided they are so linked as to form a <u>single inventive concept</u>. Please note that claims for a product are specifically authorized for examination together with claims for one process specially adapted for the use of that product. This is exactly the type of case for which the rule was promulgated, i.e., to avoid burdensome and unnecessary restrictions. It is also asserted that the requirement to restrict the present application would be an unnecessary burden upon the Applicants and the Examiner's failure to follow the mandates of the statute and regulation would be a denial of due process. For these reasons it is respectfully urged that the restriction requirement be rescinded.

In addition, since the method claims contain all of the limitations of the article claims, the method claims should be rejoined under In Re Ochiai 37 USPQ2d 1127 and In re Brouwer 37 USPQ 1663.

The Examiner has rejected claims 1-12, 15 and 16 under 35 U.S.C. 102(a) as being anticipated by U.S. patent 6,261,469 to Zakhidov et al (Zakhidov and Baughman are coinventors for this application). It is respectfully submitted that the rejection has been overcome by the instant amendment. The claims have been amended to specify that the photonic crystals or photonic devices of the claimed invention are *light emitting or light transmitting*. This feature is neither taught nor suggested by the applied references.

The invention provides a light emitting or light transmitting photonic crystal which comprises a two dimensionally periodic or three dimensionally *periodic microporous* structural matrix of interconnecting, crystallographically oriented, monodispersed members having voids between adjacent members, and said members additionally having *randomly nanoporous surface porosity superimposed on the microporosity*. The invention also provides a light emitting or light transmitting photonic device or structure formed therefrom.

As described in detail in Applicants' disclosure, several process steps are conducted to produce a two dimensionally periodic or three dimensionally periodic microporous structure. From this point, the microporous structure is then provided with ***randomly nanoporous surface porosity*** *superimposed on the microporosity* to produce the structure of the invention, that couples the advantages of porous silicon and photonic bandgap materials. The structure has periodic close packed hollow members with enormous surface area and a hierarchical pore structure. In addition, they are porous at nano-scale level, resulting in photo- and electro-luminescence.

This is accomplished by etching the micropore members to provide a superimposed nanoporous surface porosity comprising nanopores having an average pore diameter which is less than about 10 nm. The members are provided with randomly nanoporous surface porosity by a wet etch or gas phase etch. For example, the members may be provided with randomly nanoporous surface porosity by chemical etching, chemical vapor etching, electrochemical etching or chemical stain etching.

The nanoporosity is responsible for the emission of light, and the periodic microporosity of the photonic crystal structure controls the propagation of the emitted photons. Compared to conventional porous silicon, the claimed material has a much larger active surface area since the whole volume of the material is used in the process for creating nanoporosity. The nanoporosity is created on the device after the periodic microporosity has been created. This is unlike the process for the formation of conventional porous silicon via various chemical etching processes where only the surface of the bulk silicon is exposed to an etchant. Thus, the photoluminescence in these silicon nanofoams is enhanced by about ten-fold over conventional porous silicon.

Zakhidov does teach the formation of three-dimensionally periodic *microporous* structures and functional composites. The formation of their structures involves first assembling monodispersed spheres of a material A (e.g. SiO_2) into an "opal-like" lattice. These spheres are then joined together by sintering, and this sintered structure is then used as a template for obtaining a three-dimensionally periodic assembly of a material B which is infiltrated into the lattice. After this infiltration, the initial material A is removed, leaving behind a hollow structure that is an inverse replica of the original lattice structure.

However, Zakhidov does not further teach or suggest any steps by which a randomly nanoporous surface porosity is provided on the microporous structure *to produce a light emitting or light transmitting structure*. While Zakidov teaches spheres having diameters of 20 nm-100 μm and pore diameters of 4-10Ă, thee is no showing of nanopors superimposed onto micropores to achieve a light emitting or light transmitting photonic crystal.

For example, Zakhidov describes that their primary opal template can be exposed to a chemical that alters the surface energy or structure of the opal *prior to the infiltration of material B*. Additionally, the reference describes other etching steps that are related to the extraction of their SiO_2 spheres with an acid or base or other solvating or reacting

chemical. This is very different than the invention described by Applicants. The two-dimensionally or three-dimensionally-periodic microporous structure of the presently claimed invention is generally formed by the following sequence of steps:

(a) crystallizing spheres of material A into a first structure having three-dimensional periodicity, and voids between spheres, wherein the material A is mechanically and thermally stable to at least about 600° C.,

(b) treating this first structure so that necks are formed between the spheres of material A,

(c) infiltrating said first structure with material B to form a A-B composite structure,

(d) removing material A from said A-B composite structure to form a second structure comprising material B; *and then*

(e) providing surface of said second structure with randomly nanoporous surface porosity.

Zakhidov et al. do not describe a light emitting or light transmitting structure which is provided with a randomly nanoporous surface porosity as described in step (e). Rather, Zakhidov et al. discuss steps for the removal of their material A from an A-B composite structure. In no respect does the reference teach or suggest providing a randomly nanoporous surface porosity on the micropores as defined by Applicants. Accordingly, the structure as described by Applicants is structurally different than any structure described by Zakhidov et al. This nanoporosity of silicon is responsible for the emission of light, while the periodic microporosity of the photonic crystal structure will control the propagation of the emitted photons. Compared to conventional porous silicon, this new material has much larger active surface area since the whole volume of the material is used in the process for creating nanoporosity, whereby the nanoporosity is created on the device after the periodic microporosity has been created. This is unlike any other process for the formation of porous silicon via various chemical etching processes where only the surface of the bulk silicon is exposed to an etchant.

While Zakhidov et al. does explain that methods commonly employed for increasing the surface of carbon may be used for increasing the surface of carbon-based opals and

inverse opals. However, carbon is neither a light emitting nor a light transmitting material. More importantly, Zakhidov et al. does not teach or suggest any microporous structure having randomly nanoporous surface porosity which is also capable of emitting and/or transmitting light.

For these reasons, it is respectfully asserted that Zakhidov et al. do not teach every element of the claimed invention, and that the claimed invention is not anticipated by Zakhidov et al.

The Examiner has rejected claims 13 and 14 under 35 U.S.C. 103(a) over Zakhidov et al. in view of Russell et al. (U.S. patent 6,093,941). It is respectfully submitted that the rejection has been overcome by the instant amendment.

The arguments with regard to Zakhidov et al. apply equally herein and are repeated from above. Russell et al. teaches a light emitting photonic structure having a transparent substrate supporting a layer of group IV semiconductor material having at least one porous region. The Examiner has applied Russell et al. to show that a photonic band gap material can be deposited on a sapphire substrate. It is respectfully asserted that the combination with Russell et al. fails to overcome the differences between Zakhidov et al. the claimed invention as amended. More specifically, the combination of Zakhidov et al. and Russell et al. still fails to teach or suggest a microporous structure having superimposed randomly nanoporous surface porosity which is also capable of emitting and/or transmitting light. For these reasons, it is submitted that the rejection has been overcome and should be withdrawn.

The Examiner has rejected claim 17 under 35 U.S.C. 103(a) over Zakhidov et al. in view of Koops (U.S. patent 6,064,506). It is respectfully submitted that the rejection has been overcome by the instant amendment.

The arguments with regard to Zakhidov et al. apply equally herein and are repeated from above. Koops teaches an optical multipath switch with electrically switchable photonic crystals. The Examiner has applied Koops to show that it would be obvious to have a liquid crystal material imbibed on the photonic crystal of the invention. However, similar to Russell et al., the combination with Koops fails to overcome the differences between Zakhidov et al. the claimed invention as amended. More specifically, the combination of Zakhidov et al. and Koops still fails to teach or suggest a microporous structure having superimposed randomly nanoporous surface porosity which is also capable of emitting and/or transmitting light. For these reasons, it is submitted that the rejection has been overcome and should be withdrawn.

The Examiner has rejected claims 45, 46, 48 and 49 under 35 U.S.C. 103(a) over Zakhidov et al. in view of Jewell (U.S. patent 5,617,445). It is respectfully submitted that the rejection has been overcome by the instant amendment.

The arguments with regard to Zakhidov et al. apply equally herein and are repeated from above. Jewell teaches a quantum cavity light emitting element having cavities and a light emitting material within the cavities. The Examiner has applied Jewell to show that it would be obvious to deposit a metal layer on opposite surfaces of a photonic crystal. The Examiner has also applied Jewell to show that it would be obvious to have a light emitter positioned to direct light onto the photonic crystal of the invention, and also to show that it would be obvious for such a light emitter to transmit light having the claimed wavelength range. However, similar to Russell et al. and Koops, it is respectfully asserted that the combination of Zakhidov et al. with Jewell fails to overcome the differences between Zakhidov et al. the claimed invention as amended. More specifically, the combination of Zakhidov et al. and Jewell still fails to teach or suggest a microporous structure having superimposed randomly nanoporous surface porosity which is also capable of emitting and/or transmitting light. For these reasons, it is submitted that the rejection has been overcome and should be withdrawn.

The Examiner has rejected claim 47 under 35 U.S.C. 103(a) over Zakhidov et al. in view of Jewell and further in view of Koyama et al. (U.S. patent 6,462,356). It is respectfully submitted that the rejection has been overcome by the instant amendment.

The arguments with regard to Zakhidov et al. and Jewell apply equally herein and are repeated from above. Koyama et al. teaches a light emitting device having a light emitting section and a waveguide section on a substrate, which waveguide section transmits light from the light emitting device section. The Examiner has applied Koyama et al. to show that it would be obvious to have an electrode attached to the electrically conductive, optically transparent layers of the claimed invention. However, similar to Russell et al. and Koops, it is respectfully asserted that the combination of Zakhidov et al. with Jewell and Koyama et al. fails to overcome the differences between Zakhidov et al. the claimed invention as amended. More specifically, the combination of Zakhidov et al., Jewell and Koyama et al. still fails to teach or suggest a microporous structure having randomly superimposed nanoporous surface porosity which is also capable of emitting and/or transmitting light. For these reasons, it is submitted that the rejection has been overcome and should be withdrawn.

The Examiner has rejected claims 1-3 and 6 under 35 U.S.C. 102(e) or 35 U.S.C. 103(a) over Ichimura et al. (U.S. patent 6,456,416). It is respectfully submitted that the rejection is not well taken.

Ichimura et al. teaches a process and device for producing a photonic crystal and optical element. More specifically, Ichimura et al. describes a process for producing an optical element comprising a photonic crystal in which spots having different indices are arranged periodically, comprising the step of exposing an optical medium whose refractive index changes by irradiation of light or by a predetermined treatment conducted after the irradiation of light according to the intensity of the applied light to a field where light intensity changes in space at a period of the wavelength order of light and holding the optical medium for a given time, and the step of repeating at least once the step of

creating another field where light intensity changes in space at a period of the wavelength order of light by shifting the optical medium. Ichimura et al. disclose that their optical medium may be a porous material with a photopolymerizable monomer impregnated thereinto, and that the impregnated photopolymerizable monomer at a portion where an intensity of the irradiated light is lower than the reminder is removed by the treatment of the chemical in said forming step. However, Ichimura et al. fails to disclose each element of the claimed invention. Particularly, Ichimura et al. fail to disclose a a two dimensionally periodic or three dimensionally periodic microporous structural matrix of interconnecting, crystallographically oriented, monodispersed members having voids between adjacent members, and said members additionally having randomly nanoporous surface porosity. As discussed above, the nanoporosity is responsible for the emission of light, and the periodic microporosity of the photonic crystal structure controls the propagation of the emitted photons. Compared to conventional porous silicon, the claimed material has a much larger active surface area since the whole volume of the material is used in the process for creating nanoporosity. The nanoporosity is created on the device after the periodic microporosity has been created. This is unlike the process for the formation of conventional porous silicon via various chemical etching processes where only the surface of the bulk silicon is exposed to an etchant. Thus, the photoluminescence in these silicon nanofoams is enhanced by about ten-fold over conventional porous silicon. Ichimura neither teaches nor suggests such a light emitting or light transmitting photonic structure. For these reasons it is respectfully submitted that the rejection is incorrect and should be withdrawn.

The undersigned respectfully requests re-examination of this application and believes it is now in condition for allowance. Such action is requested. If the examiner believes there is any matter which prevents allowance of the present application, it is requested that the

undersigned be contacted to arrange for an interview which may expedite prosecution.

Respectfully submitted,

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